

LEPIDOCYCLINA
FROM
THE VERDUN FORMATION OF
NORTHWESTERN PERU

ABSTRACT OF

A DISSERTATION SUBMITTED TO THE BOARD
OF UNIVERSITY STUDIES OF THE JOHNS HOP-
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OF PHILOSOPHY

BY

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INTRODUCTION ¹

The material upon which the following work is based was collected by myself and wife on Sundays and holidays during 1927 and 1928. This collecting was made possible through the kindness of Mr. Oscar Haught who gave us the use of his car and acted as driver for us, and to whom grateful acknowledgment is due. The material was collected from the "gritty" phase of the Verdun formation exposed about six and one half ($6\frac{1}{2}$) miles N. 46° E. of Point of Parinas, four and one half ($4\frac{1}{2}$) miles N. 45° E. of Negritos, and two and one half ($2\frac{1}{2}$) miles S. 29° E. of the Port of Talara, all in the Department of Piura, northwestern Peru, South America. (See map).

The author wishes to thank Dr. Maynard M. Metcalf and Dr. S. O. Mast of the Johns Hopkins University for suggestions and criticisms of certain biologic features. His thanks are also due to the members of the Geologic Department, both faculty and students.

HISTORICAL SKETCH

The literature dealing with the micropaleontology of the Tertiary rocks of northern Peru is very meager and gives but slight help as to the detailed age and character of the Tertiary of the region. For the most part the older papers like that of D'Orbigny ² are of mixed collections of both recent and fossil material and from various geologic horizons. Gabb ³ mentions the occurrence of one Foraminifera, a Fusi-

¹ The work was suggested by Professor Edward W. Berry and it was under his direction and supervision that the present study was made.

² D'Orbigny, Alcide, *Voyage dans l'Amerique Meridional, Paleontologie et Géologie*. Vol. 3, pt. 3, 4.

³ Gabb, W. M., *Jour. Acad. Nat. Sci. Phil. n. s.* vol. 8, p. 263, 1877.

lina, from northwestern Peru, in 1877. From that time until 1920 when H. Douvillé ⁴ mentioned a species of Nummulites, no references are made to the Foraminifera from Peru. In 1921 however Dr. Carlos I. Lisson of Lima described and figured a species of *Lepidocyclina*—*L. r. douvillé* ⁵ from Organos Chicos, northwestern Peru. In the same paper he mentions the occurrence of Nummulites at Saman and Orthophragmina at Lagunitos. The same year Dr. J. A. Cushman ⁶ described two species of *Lepidocyclina* and one species of Orthophragmina from near the same localities. In 1927 Dr. A. Tobler ⁷ makes mention of the occurrence of larger Foraminifera at several localities in northwestern Peru. I have also published several small papers dealing with the smaller Foraminifera of northwestern Peru.

All the work, however, of a paleontologic nature has dealt with the Eocene Foraminifera only.

Olsson and Iddings in their paper on Geology of Northwestern Peru ⁸ mention the occurrence of Oligocene beds in northwestern Peru. These beds are designated as follows: On top of the definitely determined Saman rocks of upper Eocene age there is a thick series of shales, sandstones, and conglomerates. "These rocks belong to the Oligocene and have a thickness of more than 7000 feet." ⁹ The only pre-

⁴ Douvillé, H. *Compte Rendu somm. Soc. Géol. Fr.* No. 14, 1920. p. 193.

⁵ Lisson C. H. *Contribucion al Estudio de Algunos Foraminiferos Terciarios provenientes de la Region del Norte del Peru.* Archivos de la Asociacion Peruana para el progreso de la Ciencia Tome 1, Fac. 1, p. 52, 1921.

⁶ Cushman, J. A., in *Bosworth Geol. and Paleo. of N. W. Peru* p. 136, 1922, Macmillan Co.

⁷ Tobler, A. *Neue Funde von obereocänen Grossforaminiferi in der nordperuanischen Kustenregion.* *Eclogae Géologicae Helvetiae* Vol. XX, No. 3 pp. 415-421, 1927.

⁸ Olsson and Iddings *Bull. A.A.P.G.* Vol. 12 No. 1, pp. 1-39, 1928.

⁹ *Idem.* page 19.

vious mention of Oligocene in northwestern Peru is by Grzybowski ¹⁰ in 1899 when he named the Ovibio formation. This formation has not since been recognized, or the locality found.

Olsson and Iddings further divide the Oligocene into the following formations:

Upper Oligocene—Heath formation.

Middle Oligocene—Mancora formation.

(Punta Bravo grits)

Lower Oligocene—Chira formation.

(Bayobar formation)

(Verdun formation)

In their generalized columnar section of northwestern Peru ¹¹ they divide it as follows:

Upper Oligocene—Heath formation.

(Caleta Mero Shales)

Middle Oligocene—Mancora formation.

(Mirador)

(Punta Bravo grits)

Lower Oligocene—Chira formation.

(Bayobar formation)

(Sal Chica beds)

Verdun formation

(Orbitoid ss)

(Chacritos grits)

DESCRIPTION OF THE DEPOSITS

The beds which we are here interested in have been called Verdun formation which is the same series of sandstones and shales in both columns in the accompanying table of formations. They are classed as lower Oligocene. They are well exposed in the region north and northeast of Negritos,

¹⁰ Grzybowski, J. Die Tertiärlagerungen des nördlichen Peru und ihr Molluskenfauna. Neues Jahrbuch für Min. Geol. Paleont. Beilage-Band XII. Pp. 610-614, Taf. XV-XX, 1899.

¹¹ Olsson and Iddings Idem. p. 10.

Peru. Here they consist of about 1000 feet of sediments made up of shales, sandstones, and "grits." The lower 700 feet are largely composed of fairly hard, gray shales with two thin bands of light gray sandstone and occasional streaks of limonite shale, usually less than one inch thick. Overlying this 700 feet of shales are approximately 300 feet of fine to coarse sandstone and grits. The term grits is used here for fairly coarse sandy sediments of which the grains are angular (gritty) and where there is more or less calcareous cement present.¹² In these grits the grains may run up to 2 mm. in their long axes and are usually very angular. In these sandstones and grits are a few beds of shale very similar to the shales below the sandstones and grit series. The shales often contain a few agglutinated foraminifera belonging to the genera *Ammodiscus*, *Cyclammina*, *Reopax*, and *Trochammina*, most prolific both in actual numbers and in number of species, there being probably ten different species of *Trochammina* in the formation.

The sandstone and grit beds, particularly the grit beds, contain many Orbitoidal Foraminifera. These, as far as I know, all belong to the genus *Lepidocyclina*. It is these fossils which are described in this paper.

COLLECTING OF SAMPLES

The *Lepidocyclina* described in this paper were collected by trenching the formation at right angles to the strike. The trench was about three feet deep and one to two feet wide. The material was collected from the bottom of the ditch and samples taken of the entire section foot by foot. These samples were later washed up, *i. e.*, the fine shaley and silty materials were washed out and the sandstone and grits reduced as much as possible to individual grains. This freed most of the fossils from their matrix. Later the dried mate-

¹² Holmes, A. *Nomenclature of Petrology*—D. Van Nostrand Co., N. Y., 1920, p. 114.

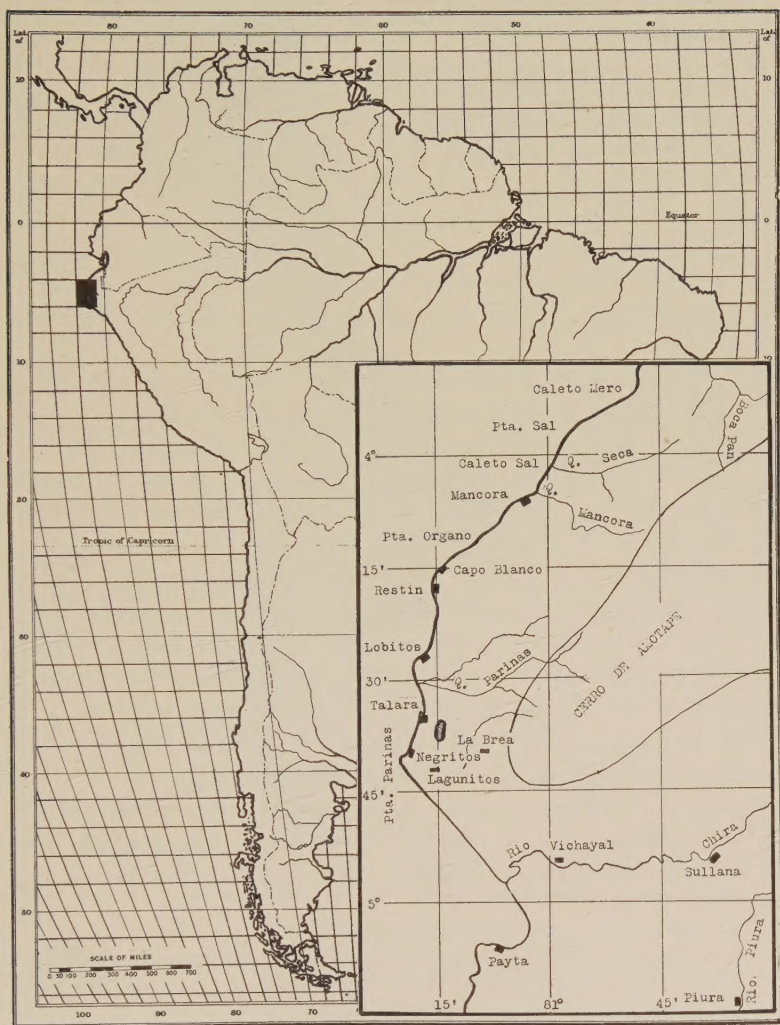


Fig. 1. Map of South America showing location of area of inset

rial was picked over under the microscope and all the *Lepidocyclina* saved. These were then sorted, sectioned, and studied.

ENVIRONMENTAL CONDITIONS

The fauna described in this paper comprise 70 species and one variety all belonging to *Lepidocyclina* and all new to science. Of these 72 species and varieties 69 are megalospheric and only 3 are microspheric.

In a discussion of these forms it is very hard to arrive at any conclusions as to their exact age. To the best of my knowledge they are not comparable with any known described forms.

In the first place they are extremely small in size for this genus, ranging from slightly over 3 mm. in diameter to less than 0.5 mm. in diameter. One species, *Lepidocyclina r. douvillé* Lisson, which is somewhat similar in size to the above, has been described from the Eocene of the region.¹³ This form is identical with *L. peruviana* Cushman 1922, according to Vaughan.¹⁴ However, this form differs from the above described forms in having the equatorial chambers hexagonal to square whereas all of my forms except three have arcuate, ogival, or rhombic equatorial chambers. Of the three forms having hexagonal equatorial chambers one is microspheric and the other two differ in the dimensions of the nucleoconch and rest of the chambers, both equatorial and lateral. Another species of *Lepidocyclina* which is of about the same size, *L. (Isolepidina) boetonensis* Van der Vlerk, is described from the Tempilan beds, Boeton, E. Celebes.¹⁵

¹³ Lisson, Carlos I. Contribucion al estudio de algunos foraminiferos terciarios provenientes de la region del Norte del Peru., Archivos Asociacion Peruana para el Progreso de la Ciencia, Tomo 1, Fac. 1, pp. 52-54. 1921.

¹⁴ Vaughan, T. W. American and European Tertiary larger Foraminifera Bull. Geol. Soc. Am. Vol. 35, 1924. p. 794.

¹⁵ Van der Vlerk, I. M. The Genus *Lepidocyclina* in the Far East, Eclogae Géological Helvetiae Vol. 21, No. 1, June, 1928, pp. 182-211.

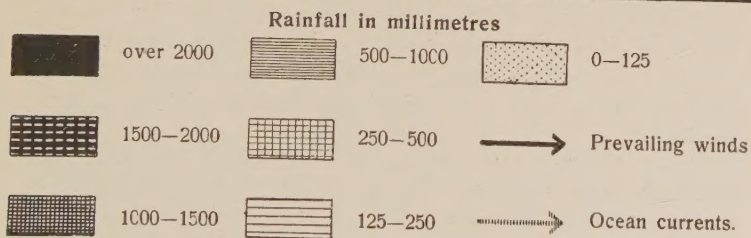
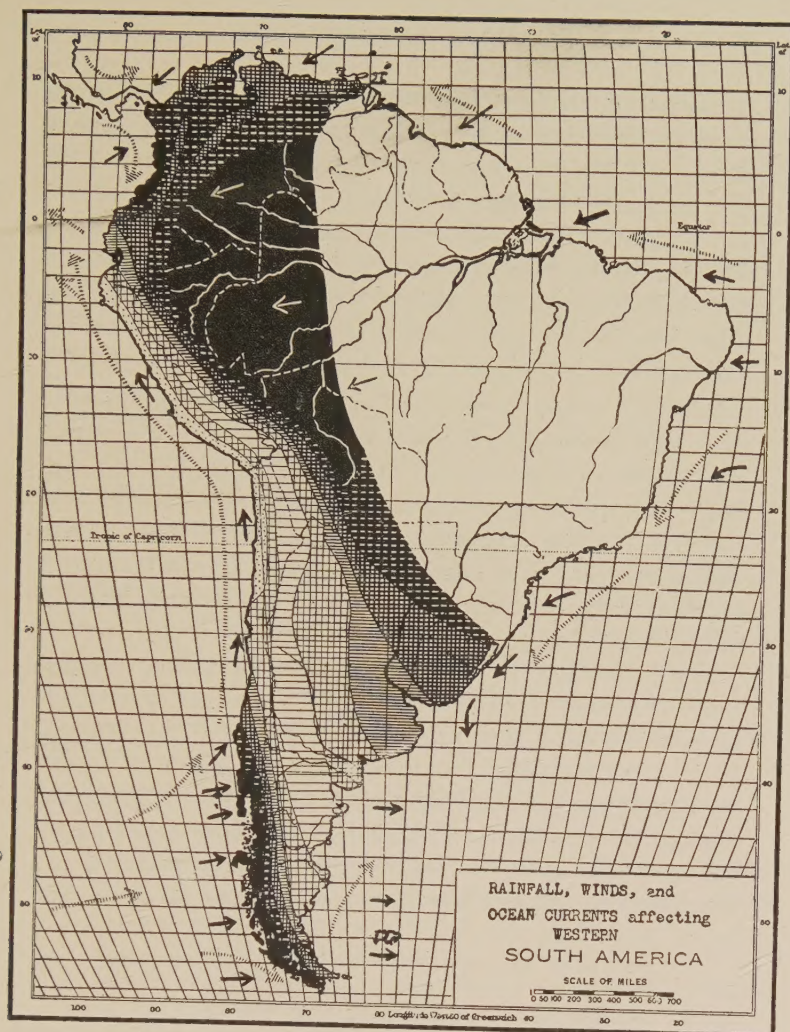


Fig. 2. Climatic Map of South America

These beds according to Van der Vlerk and Dickerson¹⁶ are probably Oligocene in age. This species also has hexagonal equatorial chambers but again differs from my forms in that the other chambers are unlike. A third small species, *L. subglobosa* Nuttall, has been described from Trinidad.¹⁷ This species has lozenge shaped equatorial chambers whereas none of mine have such shaped chambers. As regards the other described *Lepidocyclinas* of the subgenus *Isolepidocyclina* I have been unable to find any which are comparable.

In all my forms the very noticeable feature of smallness is their most outstanding characteristic. This feature of small size is not confined to this formation, however. In my description of the Restin Foraminifera¹⁸ I called attention to this fact. In the formations from the Restin shale to the base of the Verdun formation I have found a great deficiency of small calcareous foraminifera. In the Saman Shale¹⁹ with a total fauna of 75 species of Foraminifera there are 16 definitely arenaceous forms and 59 are calcareous species. There is a larger number here of calcareous species but they are for the most part rare and uncommon in occurrence, whereas the 16 species of arenaceous forms make up by far the largest percentage of the forms. The Saman Sandstone contains some calcareous Foraminifera exclusive of the larger Foraminifera but the arenaceous forms such as *Ammodiscus*, *Trochammina* and *Cyclammina* are by far the most common

¹⁶ Van der Vlerk, I. M., and Dickerson, R. E. Distinction among certain genera of larger Foraminifera for the Field Geologist of the East Indies. Jour. Paleon. Vol. I, No. 3, 1927, pp. 185-192.

¹⁷ Nuttall, W. L. F. Tertiary Foraminifera from the Naparina Region of Trinidad. Quart. Jour. Geol. Soc., Vol. LXXXIV, p. 104, 1928.

¹⁸ Berry, E. Willard, The Foraminifera of the Restin Shale of Northwest Peru, Eclogae Géologiques Helvetiae, Vol. 21, No. 1, 1928, pp. 130-135.

¹⁹ Berry, E. Willard, The Smaller Foraminifera of the Middle Lóbitos Shale of Northwestern Peru. Eclogae Géologicae Helvetiae, Vol. 21, No. 2, 1928, pp. 390-405.

and abundant forms. The Pozo Shale has 21 species of arenaceous forms against 5 with calcareous tests, while the basal portions of the Verdun formation which is mainly shale has 29 arenaceous species and only 2 species with calcareous tests. The "gritty" part of the formation which contains so many *Lepidocyclina* contains a few arenaceous species and none with calcareous tests except the larger Foraminifera. However, the ratio of calcareous tests to arenaceous tests seems to have no bearing on the dwarf faunas. I think that the Restin forams and the "gritty" phase of the Verdun had more similar environmental conditions than the others.

The subgenus *Isolepidina* (see Map I.) is practically confined to the Americas, only one species as far as I know occurring outside of this area. That one species is *L. boetonensis* Van der Vlerk from E. Celebes (East Indies). *Isolepidina* is usually found only in the Eocene and Oligocene. Most of the described species are large with the exception of the three species already mentioned. However, those which I have described are all small with the exception of the microspheric form which is upward of 6 to 7 mm. in diameter.

The reason for this small size may be due to several different causes, as follows:—I. Cold water and lack of calcium carbonate (sic.), II. Warm waters, swift deposition, and lack of food, III. Rapid sedimentation, IV. Salinity, V. Hydrogen Ion concentration. I will consider these in the order given.

I. Cold waters and lack of CaCO_3 .

I know of no evidence which would necessitate a cold Oligocene climate in the area such as is found on the west coast of South America. At the present time the Andes cut off the eastern trade winds, those very continuous tropical winds, and allow the influence of the southern westerlies as embodied in the Peruvian and Humbolt currents to come farther north than would be the case if the Andes were not

elevated. In Oligocene times according to Professor Berry²⁰ the Andes were not as yet uplifted.²¹ Let us ignore the possible slight shiftings of the southern border of the tropical rain belt and assume the following conditions: The west coast of South America about where it is today, an upwelling of cool waters from the Pacific and a cold current flowing from the south, and no mountain barrier, such as the Andes, present. In the northern part of the continent the southeasternly and northeasternly trades would alternately blow from the east over the area. As these winds would have passed over quite a land area they would probably be dry but not as dry as if they had been over high mountains. However, I find no reason to believe that such was necessarily the case. Today the Amazon valley is very wet and humid and quite low in elevation. Presumably, before the uplift of the Andes it was as low if not lower in elevation. We know that much rain falls in the area of the Amazon basin. If the basin were lower, and as it is a negative element it probably was, there would be much rain brought about by local conditions giving rise to so-called thunderstorms. In Oligocene times, according to Arldt,²² the Amazon basin was more or less submerged and formed an arm of the sea. This would give a wet area where the winds could pick up more moisture. This moisture could be precipitated on or near the west coast if the land raised slightly or if a cool current flowed along the coast. This would give a somewhat cool and slightly damp climate. The salinity of the water would be a little less due to the small influx of fresh water from rains. If the cold current did not flow north

²⁰ Berry, Edward Wilber. *The Age of Uplift of the Andes*, 1925.

²¹ The climatic discussion in *Petrified Fruits and Seeds from the Oligocene of Peru* by Professor Berry, *Pan-Am. Geol.* Vol. XLVII, March, 1927, pp. 121-132, does not hold for the Oligocene as the Parí Formation is Eocene. (See Olsson and Iddings loc. cit.).

²² Arldt, Th. *Handbuch der Paleogeographie*, Leipzig, 1919, Map page 416.

along the coast you would get more humid lowland tropical climate because of the fact that there would be much rain from the Pacific winds such as occurs in western Colombia at the present time.

The first of these conditions would give cold water which is often blamed for dwarf faunas. However, I have found, living in the arctic waters of Dease Inlet in northern Alaska, several species of *Polystomella* upwards of 3 mm. in diameter. Certainly these are fairly large and do not show any dwarfing due to cold or the lack of calcium carbonate, which is often thought of in connection with cold waters. I have in my possession a small collection of recent forams from the Lobos Islands off Peru which contain many *Miolina* forms even though it is in a cold current and not in tropical waters. In fact it has been my experience to find a greater abundance of life in cold waters than in hot. The present fauna of the west coast of South America, although small in number of species, is large in the number of individuals and the shells are usually of heavy, thick-shelled species. The great destruction of bird life after the rains of 1925, which were due to a shift of the current south and the loss of the cooler waters, shows that the warm water contained less food than the cold waters. This would seem to disprove that the lack of CaCO_3 due to cold waters (?) would cause the dwarfing of forms.

II. Warm waters, swift deposition, lack of food.

It is very evident from the sediments of the Orbitoid bearing portion of the Verdun formation that they were deposited rapidly, near shore, and probably in shallow waters because the "grits" are coarse (mainly greater than 1.5 mm. in diameter) angular to slightly subangular, and poorly sorted. The rate of submergence of the area must have been relatively rapid in order to accumulate such a large thickness of similar coarse sediments (roughly 300 feet).

In the proceeding section I have suggested factors which might give warm waters in the Oligocene.

Cushman²³ says that generally, as far as is known, the food of foraminifera consists of diatoms and various other algae. Some of the pelagic forms of foraminifera are known to catch and eat copepods but we can dismiss from our discussion these pelagic forms because as far as we know the orbitoids were not pelagic but bottom dwellers, probably in clear waters.

I have found no diatome tests in these sediments or in the sediments either older or younger in the region. This would lead one to think that conditions were unfavorable for their existence at the time. The other alga, such as diatoms and soft algae, would not be able to live under conditions of such rapid sedimentation. This would bring about a deficiency of food which would account for a starved fauna. Olsson and Iddings in their *Geology of Northwestern Peru*²⁴ state that there are only "a large heavy-shelled oyster and a few mollusks of local occurrence" which lived in the Verdun formation. This would also seem to indicate a deficiency in food supply.

III: Too rapid sedimentation.

The character of the sediments indicate that they were deposited rapidly. This would tend to be an unfavorable environmental factor. In itself it would tend to cause a diminution or dying out of bottom dwelling forms by the simple process of smothering them or smothering their food supply. This does not seem to be entirely the case, however, because even though the orbitoids are small they are very abundant in these gritty sandstones. But to prevent such smothering it would seem to be necessary for the ani-

²³ Cushman, J. A. *Foraminifera, Their Classification and Economic Use*, Cush. Lab. Foram. Research. Special Pub. No. 1, 1928, p. 8.

²⁴ Iddings and Olsson, *A.A.P.G. Bull.*, Vol. 12, No. 1, 1928, p. 21.

imals to reproduce rapidly and so to keep from becoming buried by sediment.

The almost total absence of microspheric forms in the formation would seem to indicate that the megalospheric forms seldom had time to develop zoospores which would give rise to the microspheric forms but must have produced more megalospheric young.²⁵ This, however, would not seem to help as the new megalospheric young would still not be free swimming like the flagellated zoospores but would be bottom dwellers like the parents. It is known that in certain of the less complex foraminifera the animal can leave the test completely.²⁶ In this "naked" state it can move about freely and with comparative rapidity. This shedding of the test is only known in the less complex foraminifera but I can see no valid reason why it should not hold true for the more complex forms as well. If such were the case it would be simple for the megalospheric to divide and give rise to more small megalospheric young which, while not free swimming, could shed their tests and so become more active to climb up through the coarse sediments and then secrete a new test. This would seem to furnish a method of keeping themselves from smothering and also maintain the stock without alteration of generation which we know was not common among the orbitoids of Verdun time, as witnessed by the lack of microspheric forms preserved. It would also account for the great abundance of megalospheric tests.

IV. Salinity.

Dwarfing due to either increased or decreased salinity does not seem very probable. If there had been a warm, moist tropical climate there would have been a greater influx of fresh waters into the ocean. On the other hand in the

²⁵ Cushman. Foraminifera loc. cit. p. 6.

²⁶ Cushman, J. A. Shallow-water Foraminifera of the Tortugas Region. Carnegie Institution Wash. publication No. 331, 1922, p. 8.

Caribbean region there undoubtedly were such conditions at that time and there the orbitoid forms are generally large, even up to 80 or 100 mm. in diameter. However, there is every reason to believe that the speed of sedimentation was much less rapid in the Caribbean region as most of the *Lepidocyclina* occur in limestones. If, on the other hand, there was a less moist climate and consequently a lesser influx of fresh water from the land as would be brought about by a cold current like the present Humbolt or Peruvian current there would have been more rain over the ocean, and also less evaporation which would, in my estimation, bring about approximately the same salinity conditions, but very different conditions of sedimentation. Due to the coarseness and angularity I believe that the first condition must have existed, *i. e.* warm, humid tropics with much rain and rapid run off.

V. Hydrogen Ion concentration.

I feel that the concentration of hydrogen ions may play a part in the dwarfing of forms. However, I can find no work on pH which has a bearing on the question. Dr. Metcalf ²⁷ tells me however that when an aquarium containing amoebae and plants becomes acid with humic acid from the decaying plants the amoebae start to reproduce very rapidly and in consequence of the rapid reproduction do not attain such a large size as they do in less acid environment. It is well known also that bacteria do not live in swamp water which has a high pH concentration from humic acid. It would seem to me that a stage of pH concentration could be reached where little or no CaCO_3 could exist but would form acid salts.

It is quite possible that the increased pH concentration would act with *Lepidocyclina* in the same way that it acts with amoebae by causing dwarfing by rapid reproduction.

²⁷ Metcalf, M. M. Personal communication.

But to bring about such a concentration of Hydrogen Ions in marine waters would require a constant resupply of Hydrogen Ions because of the great buffer action of sea water. Such a condition would certainly, it seems to me, leave evidence in other than the dwarf fauna. Hence I believe we cannot consider this a pertinent factor in the dwarfing of the fauna.

Of these five possibilities I have discussed, I believe the lack of food because of the rapid sedimentation was the major cause of this dwarf fauna. The difference of salinity would be hard to explain even without any connection with the Caribbean region and as far as I know there is no great difference in the salinity of the present west coast waters and the average Caribbean waters. Of course if there had been anything like an Amazonian river debouching into the Oligocene embayment we would expect a difference of salinity between near the mouth of such a river and away from it, but we know of no evidence of the existence of such a river.

I do not believe cold water would account for such a dwarfing of forms. It is certainly not the fact today. I have seen the arctic beach of Alaska strewn with medusoid jelly fish upwards of 15 inches in diameter, these are certainly as large as any known tropical ones. In the mollusks the cold water forms are often as big and strong or thick shelled as the tropical forms and none can deny that in the marine mammals the largest forms are found in arctic and antarctic waters and not in the tropics.

The hydrogen Ion action is too little known in its long continued effects to be of any value as yet in determining dwarfing conditions.

In a tropical climate we often get very fast erosion and consequently rapid sedimentation and under such conditions it is very possible to have a scarcity of food which would account for the reduction in size of the small animal life and the almost total lack of larger animals such as mollusks.

AGE OF THE VERDUN

All of the *Lepidocyclinas* described in the present paper are known only from these deposits nor do they show any close relationship to described species in other areas. Hence they lack any precise value in correlation. For the exact age of the Verdun deposits as shown by these forms work will have to be done on the same genera in the upper Eocene of the area. This may show that the forms described here are in fact a continued evolution very closely related to the forms in the Saman Sandstone (upper Eocene).

Iddings and Olsson²⁸ place the Verdun formation in the Oligocene on what may be called negative evidence, *i. e.* the material underlying it is clearly upper Eocene as proved by the larger fossils and the material overlying is of Zorritos Miocene age. They find in the Verdun only a few mollusks and a large, heavy-shelled oyster both of which are of local occurrence. There are also some reworked upper Eocene fossils found.

They state that the Verdun is closely associated with the Chira shale and cannot be differentiated in the area south of Lagunitos. This may be true lithologically but on the basis of micro-fossils the difference between the Verdun and the Chira is very striking. The Chira shales may contain some orbitoids but as far as I know none have thus far been found. But they do contain many large nummulites. There are a very few nummulites in the Verdun. They are so rare that in about one thousand sections I have found only about six nummulities and these are extremely small. Those in the Chira shale are large and plentiful, so abundant in places as to make up a large percentage of the rock which is hence a true nummulitic limestone. The Chira shale also contains many smaller foraminifera. These smaller fossils are also extremely abundant and are quite like those in the Saman

²⁸ Loc. cit. p. 20.

Shale (Eocene). The Chira shale has not been completely described as yet but there are about ten species that I know of that are identical with those of the Saman Shale, and as far as I know none which are identical with those of the Verdun, either the "gritty" phase or the shaley phases. The Chira fauna is largely composed of forms with calcareous tests and has but a very few of the arenaceous forms. These arenaceous forms are few both in species and in number of individuals. The same is true in a sense of the Verdun microfossils. The two formations are not comparable in the microfossils, those of the Chira shale being more like those of the Saman Shale, excepting the proportion of calcareous to arenaceous forms. The Chira shale forms are much like those described by Galloway²⁹ from Ecuador which he thinks are probably of upper Eocene age.

The Saman Shale fauna cannot be compared with the Verdun formation because of the abundant larger fossils in it and the lack of larger fossils in the Verdun formation. The microfossils do not allow of any better comparison. There are a few Trochammina and Cyclammina found in the Verdun formation in the shaley parts but these are different species from those found in the Saman Shale.

The Saman Sandstone contains some Orbitoids but these have not been worked up. Also it is not certain that they are Saman Sandstone and not Verdun formation.

There are some orbitoid sandstones exposed near Lagunitos from which Lisson has described *Lepidocyclina r. douvillé* and which Cushman described again under the name *Lepidocyclina peruviana*. These sandstones are probably of Saman Sandstone or Saman Shale age. The *Lepidocyclina* described from there is not like any of those from the Verdun formation. I have examined the material for smaller

²⁹ Galloway, J. J., and Morrey, M. A Lower Tertiary Foraminiferal Fauna from Manta, Ecuador. Bull. Am. Paleo., Vol. 15, No. 55, Jan. 3, 1929.

foraminifera and have failed to find any, so that there can be no comparison drawn from that outcrop and the Verdun formation. There are other sandstones not known in outcrops but which have been reached by well drilling which contain many small orbitoids. These are supposed to be of Saman Sandstone age. This has not been proved. In size they seem to compare with the orbitoids of the Verdun formation but as to other features they have not been compared. If they showed great similarity they would seem to be ancestral to the Verdun rocks and would place them in the Saman group or upper Eocene. But on the other hand if they proved to be identical in most cases then the supposed Saman Sandstone in the drillings has probably been Verdun.

I have found one specimen, which has unfortunately been lost, of the genus *Helicolepidina* Tobler in the basal portion of the gritty phase of the Verdun formation. This genus has been heretofore considered of Eocene age and is often found associated with *Orthophragmina* (*Ceisses*, *Disco-cyclina*, *Asterdiscus*, etc.). No *Orthophragmina* have been found in this formation but they are present in the basal portion of the Saman Shale. It is more probable that *Helicolepidina* continued into the younger formation and is of no value in the age correlation of the Verdun formation.

Until more work is done on the other orbitoids in the formations which are of known age the Verdun formation will have to be considered Oligocene in age because of its stratigraphic position.

THE GENUS *LEPIDOCYCLINA* AND ITS SEGREGATES

The only abundant fossils in the Verdun formation are orbitoidal foraminifera of the genus *Lepidocyclina*. *Lepidocyclina* are discoidal, lenticular fossils of varying size, the smallest being less than a millimeter in diameter, the largest

about one hundred millimeters. Like the other Foraminifera there are two forms of each species, a microspheric and a megalospheric. These two forms represent alternating sexual and asexual generations. In the microspheric form the earliest or embryonic chambers are very small and are arranged in a short spire. In well preserved specimens of the microspheric form these embryonic chambers can be seen in a thin section. In the megalospheric form the embryonic chambers, called the nucleoconch, are much larger and more easily seen in thin section. The megalospheric form of any species is usually smaller than the microspheric form and often much more abundant.

In the *Lepidocyclina* (and other orbitoids) there are three distinct parts (a) the nucleoconch, (b) the equatorial chambers, a layer of chambers on the median horizontal plane of the test. These chambers are usually arranged in concentric rows. They are also called median or meridional chambers. (c) The lateral chambers which occur as several to many layers on both sides of the equatorial chambers. Pillars, solid columns, may extend from the surface of the equatorial chambers to the surface of the test where they usually form knobs called papillae. These pillars lie between the columns of lateral chambers.³⁰

To describe or recognize a species it is necessary to know the size, shape, and surface ornamentation, also the nucleoconch of the megalospheric form and its size, the shape and

³⁰ Cushman gives a diagramatic vertical section of *Lepidocyclina* showing these features. Cushman, J. A. The American species of *Orthophragmina* and *Lepidocyclina*: U. S. Geol. Survey Prof. Paper 1250, fig. 3 (p. 36), 1920.

See also—

a. Schenck, Hubert G., and Aguerrevere, Santiago E. Morphologic nomenclature of *Orbitoidal Foraminifera*: Am. Jour. Sci. 5, ser. Vol. II, fig. 3 (p. 254), 1926.

b. Van der Vlerk, I. M., and Dickerson, R. E. Distinction among certain genera of *Larger Foraminifera* for the field geologist of the East Indies. Jour. Paleon. figs. 1, 2, 3, pp. 186, 187, 188; 1927.

arrangement of the equatorial chambers, and their size; the number of lateral chambers and their size, and also the size of the pillars.

Van der Vlerk gives as principal characteristics in the distinguishing of a species the following:—the existence or non-existence of a peripheral flange, the arrangement of the columns, the diameter of the whole full grown individual, the ratio of the diameter to the thickness, the arrangement of the equatorial chambers and the shape of the outline (generally corresponding with the arrangement of the equatorial chambers), the thickness of the walls of the equatorial chambers, the dimensions of the equatorial and lateral chambers, and closely the thickness of the columns.³¹ I am following his system of characteristics in this paper.

The surface ornamentation will usually show the presence or absence of pillars and their arrangement. However it may be necessary to wear down the surface slightly to see their arrangement and their shape. The other features are only to be seen in section, preferably in thin section. Horizontal sections will show the nucleoconch and shape and arrangement of the equatorial chambers, while vertical sections will show the nucleoconch, the vertical section of the equatorial chambers, the arrangement of the lateral chambers and some of the columns. Some of the horizontal sections will not show all of the equatorial chambers due to the often present undulations of this layer of chambers. Accidental sections as often cut from rock specimens will often be of little use because of the lack of proper orientation. Where the tests may be freed from the matrix carefully orientated sections may be obtained. In my material such was the case. By careful work the tests could be freed from the matrix, and embedded in balsam under the microscope so as to get them orientated before sectioning.

³¹ Van der Vlerk, I. M. The Genus *Lepidocyclina* in the Far East. *Eclogae Géologiques Helvetiae*, Vol. 21, No. 1, p. 184. 1927.

Genus LEPIDOCYCLINA Gümbel, 1868

Test of different sizes, discoidal or saddle shaped, surface papillate or not depending on the presence or absence of pillars mainly in central thickened portion of the test. Equatorial chambers of various types on which the subgenera are based; equatorial chambers alternating in successive rows; lateral chambers relatively large, overlapping in successive layers or arranged in vertical columns between which may be pillars.

Henri Douvillé has described five subgenera of *Lepidocyclina*: 1. *Isolepidina* (*Lepidocyclina* ss) 2. *Eulepidina*. 3. *Nephrolepidina*. 4. *Pliolepidina*, and 5. *Amphilepidina*.³² Dr. Tobler in 1922 described a sixth subgenera of *Lepidocyclina*—*Helicolepidina*.³³ In 1924 Dr. T. W. Vaughan proposed still another subgenus, *Polylepidina*³⁴ and recognized the following of Douvillé's classification 2 *Pliolepidina*; 3 *Lepidocyclina* ss (*Isolepidina*); 4 *Nephrolepidina*; and 5 *Eulepidina*. He mentions *Helicolipidina* Tobler at that time but believes it to be *Spiroclypeus* as does Douvillé. In 1926 Vaughan says, "*Helicolepidina* appears to me to be a valid genus, an opinion different from the one I expressed in a previous paper."³⁵ Wegen³⁶ in 1926 recognized *Isolepidina*

³² Douvillé, H. Les Orbitoides du Danien et du Tertiaire, Ortho-phragmina et *Lepidocyclina*: Acad. Sci. Compt. Rend., tome 166, pp. 721-728. 14 text figs. 1915. Les *Lepidocyclines* et leur Evolution un genera nouveau "*Amplilepidina*" Idem. tome 175, pp. 550-556. 1922.

³³ Tobler, Aug. *Helicolepidina*, ein neues Subgenus von *Lepidocyclina*, Eclogae Géological Helvetiae Vol. 17, pp. 380-384, 3 text figures. 1922.

³⁴ Vaughan, T. W. American and European Tertiary Larger foraminifera; Bull. Geol. Soc. Am. Vol. 35, pp. 785-822, pl. 30-36. 1924.

³⁵ Vaughan, T. W. Foraminifera from the Upper Eocene Deposits of the Coast of Ecuador. Proc. Nat. Acad. Sci. Vol. 12, No. 8, pp. 533-535, Aug., 1926. See page 534.

³⁶ Wegen, W. A. Phylogenetic Considerations of the Nummulitidae Proc. Fourth Dutch East Indian Congress of Natural Science, Weltevreden (Java), Sept. 22-26, 1926, Geographic Geologic Section, 1927, pp. 448-466, 3 charts.

STRUCTURAL PARTICULARITIES, STRATIGRAPHIC RANGE AND PALEOGEOGRAPHIC
DISTRIBUTION OF THE SIX SUB-GENERA OF LEPIDOCYCLINA GÜMBEL
MOSTLY AFTER H. DOUVILLÉ 1924-25

SUB-GENERA OF LEPIDOCYCLINA	PROVINCE	STRATIGRAPHIC RANGE	EMBRYONAL CHAMBERS OF MICROSPHERIC (A—) FORM	SUPPLEMENTARY CHARACTERISTICS RELATING TO MEDIAN CHAMBERS, PILLARS AND SHAPE.
ISOLEPIDINA Douvillé	Probably exclusively American province.	From Bartonian to lower Stampian.	Similar or nearly similar chambers separated by a flat partition, primitive.	Pillars regularly developed and rather numerous.
EULEPIDINA Douvillé	All three provinces.	From Stampian to Upper Aquitanian.	One chamber covers com- pletely the other. (—em- bracing type.). Evolute character.	Chambers like spatula, with transition to hexagonal nets. Partitions of chambers relatively thick, especially those of the equatorial section, pil- lars numerous in the young forms, often disappearing rapidly with growth.
NEPHROLE- PIDINA Douvillé	All three provinces, especially well developed in the European.	From Stampian to end of Burdigalian, doubtful in Vindo- bonian.	Dissimilar chambers. A small rounded one and a kidney shaped one (—reinform). Evolute character.	Chambers diamond shaped or pointed in arches, pillars become pustules sur- rounded by numerous chambers.
AMPHILEPI- DINA Douvillé	Almost exclusively in the Australa- sian province.	Aquitanian and Burdi- galian, doubtful in Vindobonian.	Transition type, derived from EU- and NEPHROLEPIDINA. Characteristics like those of: EULEPIDINA (chambers like spat- ule, but width of equatorial cham- bers much smaller than those of the EULEPIDINA).	
PLIOLEPIDINA Douvillé	Few specimens only in American and Austrian province.	<i>P. tobleri</i> in Stampian of America, <i>P. rufi-</i> <i>temi</i> in Vindobonian of Java (Tji La- nang.)	Irregular, a great many ir- regular chambers replace the embryo, Teratologic cause?	Form of chambers and arrangement the same as in the other sub-genera.
HELICOLEPI- DINA Tobler	American province.	Priabonian of Trini- dad and western Venezuela.	Globular first chamber, hemi- ispheric second chamber.	Inner part of median section spiral with primary and secondary spiral chambers, outer part cyclic (normal median chambers) spiral character inherited from Arnaudiella (?). (—spiral type) ancestral character.



Fig. 3. Map showing the Distribution of the Subgenus *Lepidocyclina* ss

(*Lepidocyclina*), *Eulepidina*, *Nephrolepidina*, *Amphilepidina*, *Pliolipidina*, *Helicolepidina*. (See Chart). Van der Vlerk the next year proposed a new subgenus for the Indian Archipelago—*Trybliolepidina*³⁷ and recognized for that region *Eulepidina*, *Nephrolepidina*, *Isolepidina* (*Lepidocyclina* ss), and *Pliolipidina*. He places Douvillé's *Amphilepidina* in his subgenus *Nephrolepidina*. In 1928 J. J. Galloway raised the subgenera to generic rank and recognized 1. *Helicolepidina*, 2. *Polylepidina*, 3. *Pliolepidina*, 4. *Cyclosiphon* (*Lepidocyclina* ss and *Isolepidina*), subgenus *Cyclosiphon*, subgenus *Nephrolepidina*, subgenus *Amphilepidina*, subgenus *Eulepidina*.³⁸

The genus *Lepidocyclina* first appears in the Eocene of Italy and other parts of the Mediterranean region. In Southern France the earliest species come from the Tongrian or Lattorfian (Lower Oligocene) and the genus disappears in the Burdigalian (Miocene). In the East Indies the genus first appears in the Tempilan beds (Oligocene) and disappears in the Mentaivir beds (Miocene). In the West Indies and Panama *Lepidocyclina* are found in deposits of later upper Oligocene age (Aquitania—considered lower Miocene by most European geologists). In the United States the earliest *Lepidocyclina* are found in the Ocala limestone of Upper Eocene age (Jackson) and disappear in the Bryam calcareous marl of upper Oligocene age (Chattian).

I have not followed the recent classification of Galloway but prefer to use the generic name *Lepidocyclina* and subdivide it as has been done into the following subgenera: 1. *Helicolepidina* Tobler, 2. *Polylepidina* Vaughan, 3. *Pliolepidina* Douvillé, 4. *Lepidocyclina* ss (*Isolepidina*) Douvillé, 5. *Nephrolepidina* Douvillé, 6. *Amphilepidina* Dou-

³⁷ Van der Vlerk Idem, 1927, p. 183.

³⁸ Galloway, J. J. A revision of the Family Orbitoididae, Jour. of Paleontology, Vol. 2, No. 1, pp. 45-69, 1928.

villé, 7. *Eulepidina* Douvillé, 8. *Trybliolepidina* Van der Vlerk.

1. Subgenus *Helicolepidina* Tobler, 1922.

Type (Monotypic) *Lepidocyclina* (*Helicolepidina*) *spiralis* Tobler, Eclogae Géol. Helvetiae, Vol. 17, 1922, p. 380, figs. 1-3. (Upper Eocene, Jackson, Res San Pedro, Venezuela.): Douvillé, H., *ibid.*, 1923, p. 566, Bull. Soc. Géol. France, ser. 4, Vol. 23, 1923, p. 369: Vaughan, T. W. Bull. Geol. Soc. America No. 35, 1924, p. 802: Vaughan, T. W. Proc. Nat. Acad. Sci. Vol. 12, 1926, p. 533: Hodson, H. K. Bull. Am. Pal., Vol. 12, No. 47, 1926, p. 6: Galloway, J. J. Jour. Pal. Vol. 12, No. 1, 1928, p. 60.

Test discoidal, consisting of an equatorial zone of chambers between lateral zones; the equatorial zone is one chamber thick, and composed of chambers which are arcuate on the outside and varying to ogival, spatulate and subhexagonal, and arranged irregularly within rapidly widening spire, with larger chambers on the inner side of the spire; the whorls are equitant; lateral chambers arranged in tiers; surface strongly papillose; wall calcareous, those of lateral ones finely perforate; aperture an obscure V-shaped opening on the periphery; the nucleoconch in the megalospheric form consists of a spherical chamber followed by a hemispherical one; in the microspheric form, a spherical chamber followed by curved chambers as in *Camerina*. Diameter up to 4 mm.

Upper Eocene of Venezuela, Trinidad and Ecuador.

2. Subgenus *Polylepidina* Vaughan, 1924.

Type *Lepidocyclina* (*Polylepidina*) *chiapasensis* Vaughan, Bull. Geol. Soc. Am. Vol. 35, 1924, pp. 794, 807, pl. 30, fig. 1-3, text fig. 4 (Eocene 7 km. southeast of Chilon, Chiapas, Mexico.): Galloway, J. J. Jour. Pal. Vol. 1, No. 4, 1928, p. 299: Galloway, J. J. Jour. Pal. Vol. 2, No. 1, 1928, p. 60.

Test discoidal, microspheric nucleoconch consisting of a minute spherical chamber, followed by chambers which gradually enlarge, making two or three complete whorls, and gradually changing shape from that of a sector to that of an arc, the wall of the first whorl thicker than that of succeeding chambers; megalospheric nucleoconch consisting of a large, spherical chamber succeeded by 3 to 7 large but gradually decreasing arcuate chambers arranged in nearly a complete coil, not separated from the succeeding, normal, median chambers by any common, thick wall, but the walls of the first 2 or 3 chambers are thick; median chambers arcuate, with a curved outer wall and pointed or truncate proximal ends (as in *Orbitoides*), the adjacent chambers of the same annulus just touching and arranged in intersecting curves, or not touching and arranged in radial lines [*P. antillea* (Cushman)], and appearing rhombic in thick or opaque sections, with longer diameter parallel to the periphery of the test. Diameter, up to 20 mm.

Upper Cretaceous of Mexico; Upper Eocene of Vera Cruz, Alabama, Mississippi, Louisiana, and Antilles.

3. Subgenus *Pliolepidina* Douvillé, 1925.

Type (monotypic) *Pliolepidina tobleri* Douvillé, Com. Ren. Acad. Sci., Paris, Vol. 164, 1917, p. 844, figs. 5, 6, (Upper Eocene, Point Bontour, Trinidad).

Pliolepidina Douvillé, Com. Ren. Acad. Sci., Paris, Vol. 161, 1915, p. 727, fig. 34, no species named. Vaughan, Proc. Nat. Acad. Sci., Vol. 9, 1923, p. 255; Bull. Geol. Soc. Am., Vol. 35, 1924, p. 794. Douvillé, Mem. Soc. Geol. France, n. s., Vol. 1, mem. 2, 1924, p. 43, figs. 34, 35.

Multicyclina Cushman, U. S. Nat. Mus. Bull. 103, 1918, p. 96, pl. 41, figs. 2-4. Type *Lepidocyclina* (*Multicyclina*) *duplicata* Cushman (Upper Eocene, David, Panama), supposedly distinguished by several layers of median chambers near the periphery.

Megalospheric nucleoconch consisting of one large chamber with several smaller ones around it; microspheric nucleoconch planispiral with gradually enlarging chambers; median chambers spatulate, in thick or opaque sections appearing hexagonal near the center and diamond shaped near the periphery of the test, with radial diameter the longer. Diameter 2 to 14 mm.

Upper Eocene, Trinidad, Panama and Venezuela; doubtfully in the Oligocene.

4. Subgenus *Lepidocyclina* ss Gümbel (*Isolepidina* Douvillé).

Isolepidina Douvillé, 1915, typomym of *Cyclosiphon*. *Lepidocyclina*, sensu stricti, of authors.

Test discoidal, nucleoconch typically consisting of two subequal chambers separated by a thin, flat wall, in some species the nucleoconch consists of two unequal chambers separated by a thin, slightly curved wall, equatorial chambers arcuate, the outer wall rounded, the inner portion tapering to an obtuse apex, where the chamber wall is thick the chambers appear hexagonal.

Range: Upper Eocene and Oligocene.

5. Subgenus *Nephrolepidina* Douvillé, 1911.

Type (designated by Yabe, 1911) *Cyclosiphon* (*Nephrolepidina*) *marginatus* (Michelotti)—*Nummulites marginata* Michelotti, Mem. Soc. Ital. Sci., Vol. 22, 1842, p. 297, pl. 3, fig. 4. (Upper Oligocene, or Lower Miocene, near Turin, Italy).

Nephrolepidina Douvillé, Philippine Jour. Sci., sec. D, Vol. 6, No. 2, 1911, pp. 59, 73; Com. Ren. Acad. Sci., Paris, Vol. 161, 1915, p. 727, fig. 33.—Yabe, Sci. Rep. Tohoku Imp. Univ., Sendai, Japan, ser. 2, Geol., Vol. 5, no. 2, 1919, pp. 41, 47. Douvillé, Com. Ren. Acad. Sci., Paris, Vol. 175, 1922, p. 552; Mem. Soc. Geol. France, n.s., Vol. 1, mem. 2, 1924, p. 46. Yabe and Hanzewa, Verh. geol. Mijnb. Gen. Nederland Kol., Geol. Ser., Vol. 8, 1925, p. 617.

Lepidocyclina (part) Lemoine and Douvillé, Mem. Soc. Geol. Pal., mem. 32, 1904, p. 16, pl. 2, fig. 7, type of *Nummulites marginata* Michelotti refigured.

Nucleoconch consisting of two unequal chambers, the smaller one about half surrounded by the larger one, both enclosed in a thick wall; equatorial chambers ogival.

Range: Upper Eocene to Lower Miocene.

6. Subgenus *Amphilepidina* Douvillé, 1922.

Type (first species, here designated) *Cyclosiphon* (*Amphilepidina*) *sumatrensis* (Brady)—*Orbitoides sumatrensis* Brady, Geol. Mag., dec. 2, Vol. 2, 1875, p. 536, pl. 14, fig. 3, (Upper Oligocene or Lower Miocene, Sumatra).

Orbitoides (*Lepidocyclina*) Newton and Holland, Ann. Mag. Nat. Hist., ser. 7, Vol. 3, 1899, p. 259, pl. 10, figs. 7, 8. Type refigured.

Amphilepidina Douvillé, Com. Ren. Acad. Sci., Paris, Vol. 175, 1922, p. 553; Mem. Soc. Geol. France, n.s., Vol. 1, mem. 2, 1924, p. 44.—Vaughan, Proc. Nat. Sci., Vol. 12, 1926, p. 520.

Nucleoconch the same as in the subgenus *Nephrolepidina*, differs in having equatorial chambers spatulate.

Range: upper Eocene to lower Miocene.

This subgenus is not used by Van der Vlerk in his work on the Far East,³⁹ but is included in the subgenus *Nephrolepidina*.

7. Subgenus *Eulepidina* Douvillé, 1911.

Type (designated by Yabe, 1919) *Cyclosiphon* (*Eulepidina*) *dilatatus* (Michelotti)—*Orbitoides dilatata* Michelotti, Nat. Verh. Holland. Maat. Wet. Haarlem, vol. 15, 1861, p. 17, pl. 1, figs. 1, 2. ("Lower Miocene" northern Italy.)

Eulepidina Douvillé, Philippine Jour. Sci., sec. D, Vol. 6, no. 2, 1911, p. 59; Com. Ren. Acad. Sci. Paris, Vol. 161,

³⁹ Van der Vlerk, I. M. The Genus *Lepidocyclina* in the Far East. Eclogae Géologiques Helvetiae, Vol. 21, No. 1, 1928, p. 183, 186.

1915, p. 726, figs. 31, 32, *ibid.*, Vol. 175, 1922, p. 552; Mem. Soc. Geol. France, n.s., Vol. 1, mem. 2, 1924, p. 48.—Yabe, Sci. Rep. Tohoku Imp. Univ., Sendai, Japan, ser. 2, Geol., Vol. 5, no. 2, 1919, p. 41.—Vaughan, Bull. Geol. Soc. Am., Vol. 35, 1924, p. 794.—Nuttall, Quart. Jour. Geol. Soc. London, Vol. 82, pt. 1, 1926, p. 22.

Lepidocyclina (part) Lemoine and Douvillé, Mem. Geol. Pal., mem. 32, 1904, p. 13, fig. 3, after the figure by Michelotti.

Nucleoconch consisting of two spherical chambers, the larger completely embracing the others, the two touching tangentially, the whole surrounded by a thick wall; equatorial chambers spatulate.

Range: Oligocene, Lower Miocene and Pliocene.

8. Subgenus *Trybliolepidina* Van der Vlerk, 1927.

Type (first species, here designated). *Trybliolepidina ephippoides*.—*Lepidocyclina ephippoides* Jones and Parker, A Monograph of Christmas Island, Vol. 1, pp. 251-252, pl. 20, fig. 9 (not p. 256, pl. 21, fig. 15.) 1900.—Van der Vlerk, I. M., Eclogae Géologiques Helvetiae, Vol. 21, No. 1, 1928, pp. 183, 185, 186, fig. 10 a-c.

Nucleoconch bicellular, the nucleoconch shaped like a cupule, in the equatorial section the "initial chamber is a rounded square; one side of the square coincides with the flat part of the second chamber." (Van der Vlerk 1928.)

Range: upper part of the Tertiary in the Far East.

SYSTEMATIC PALEONTOLOGY

Genus LEPIDOCYCLINA Gümbel.

1. Subgenus HELICOLEPIDINA Tobler.

Helicolepidina ? *sp.*

PLATE XXII—Fig. 2

One specimen was found in the material I had which by the equatorial section was thought to belong to this genus.

However only a rough description can be given as the specimen was lost.

It could be described roughly as follows:

Test small, circular, flattened, discoidal, diameter about 2 mm., thickness about 0.80 mm. The surface ornamented with strong papillae, in equatorial section showed a spherical chamber with a hemispherical one adjoining it, and a series of large irregular chambers in an increasing spire. This spire reached the periphery of the test in about one revolution. The other equatorial chambers were arcuate.

Occurrence: Verdun Formation, Northwestern Peru.

The specimen has been lost hence cannot be better described or figured. Because of the loss of the only specimen found this *Helicolepidina* cannot be compared to *H. spiralis* Tobler from the upper Eocene of Venezuela and Trinidad.

2. Subgenus POLYLEPIDINA Vaughn.

None found in the Verdun formation.

3. Subgenus PLIOLEPIDINA Douvillé.

None found in the Verdun formation.

4. Subgenus LEPIDOCYCLINA ss. Gümbel.

VITA

E. Willard Berry was born in Passaic, New Jersey, November 24, 1900. When he was about five years old his family moved to Baltimore, Maryland. He was graduated from the Baltimore City College in June 1919, entered the Johns Hopkins University in October of the same year and received the degree of Bachelor of Arts from the University in 1923. In October 1923 he began graduate work in the Department of Geology at Hopkins. During May to October 1921 he was assistant to C. E. Dobbin of the United States Geological Survey engaged in mapping coal in eastern Montana.

Leaving Baltimore in May 1923 he proceeded to Alaska under Sidney Paige of the U. S. G. S. on a reconnaissance of Naval Oil Reserve No. 4 in Arctic Alaska and returned in the middle of October of the same year. During May to September 1924 he was in charge of the micropaleontology laboratory of the Bureau of Economic Geology of the University of Texas. The summer of 1925 was spent at Hopkins working on collections. In October 1925 he married Miss Dorothy Everett Pidgeon of Wadesville, Virginia. In November 1925 he obtained a leave of absence from the University and went to Negritos, Peru as micropaleontologist in charge of the micropaleontological work for the International Petroleum Company. He returned to the University in November 1928 to continue his graduate studies.

He is a member of the A. A. A. S., Swiss Geological Society, and Swiss Paleontological Society.

He has published to date:—

1. Protoconchs of Caecum in the Miocene of Maryland. *The Nautilus* Vol. XXXIX, No. 2, 1925, p. 66.
2. Upper Cretaceous Ostracoda from Maryland. *Am. Jour. Sci.* Vol. IX, 1925, p. 481.
3. Description and Notes on the Life History of a New Species of *Eulimnada*. *Am. Jour. Sci.* Vol. XI, 1926, p. 429.
4. Two New Species of *Dentalium* from the Eocene of Peru. *The Nautilus* Vol. XL, 1926, p. 19.
5. The Microspheric Form of "Orthophragmina" (*Discocyclina*) *Peruviana*, Cushman. *Eclogae Geol. Helvetiae* Vol. XX, No. 3, 1927, p. 470.
6. Meteorological Observations at Negritos, Peru. *Monthly Weather Rev.* U. S. Weather Bur., Feb. 1927, p. 75.
7. Cretacic Rocks of Ecuador. *Pan-Am. Geol.* Vol. XLVIII, 1927, p. 37.
8. The Foraminifera of the Restin Shale of Northwest Peru. *Eclogae Geol. Helvetiae* Vol. XXI, No. 1, 1928, p. 130.
9. A New Nonion from Peru. *Jour. Paleon.* Vol. i, No. 4, 1928, p. 269.
10. Observations in Peru. *Science* Vol. LXVIII, No. 1762, 1928, p. 323.
11. The Smaller Foraminifera of the Middle Lobitos Shales of Northwestern Peru. *Eclogae Geol. Helvetiae* Vol. XXI, No. 2, 1928, p. 390.
12. *Asterodiscocyclina*, a New Subgenus of *Orthophragmina*. *Eclogae Geol. Helvetiae* Vol. XXI, No. 2, 1928, p. 405.
13. Two New Species of "Orthophragmina" from Calita Sal, Peru. *Jour. Wash. Acad. Sci.* Vol. XIX, 1929, pp. 142-145.
14. Two New Larger Radiolaria from the Tertiary of Peru. *Jour. Wash. Acad. Sci.* Vol. XIX, 1929, pp. 145-148.
15. Solitary Corals from the Eocene of Northwestern Peru. *Jour. Wash. Acad. Sci.*, Vol. 19, pp. 235-237, 4 figs. 1929.
16. Tertiary Brachiopoda of Northern Peru. *Jour. Wash. Acad. Sci.*, Vol. 19, pp. 237-239, 11 figs. 1929.
17. A *Gypsina* from the Eocene of Peru. *Jour. Wash. Acad. Sci.*, Vol. 19, pp. 239-240, 2 figs. 1929.

